TITLE: Cost Benefit Analysis Models for Evaluation of VMEP/HUMS Project

COST BENEFIT ANALYSIS MODELS FOR EVALUATION OF VMEP/HUMS PROJECT

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Abstract: Models for cost benefit analysis (CBA) of vibration monitoring (VM) and Health Usage Monitoring Systems (HUMS) are discussed. A brief overview of CBA methods with examples of its application to large government funded projects is given. The objectives and projected benefits of the South Carolina Army National Guard (SCARNG) Army Aviation Support Facility (AASF) Vibration Management Enhancement Program (VMEP) are briefly reviewed. The cost components associated with this activity at the SCARNG/AASF operational unit are identified and discussed. A list of most costly maintenance parts and operations is given. Possible cost savings and cost differing components are analyzed from CBA perspective. As the implementation of the VMEP project has just started, the last part of the paper presents the projected CBA evaluation results.

Key Words: Cost benefit analysis; Health usage monitoring system; Vibration management enhancement program; VMEP; HUMS; O&S; RT&B; SCARNG.

INTRODUCTION

Vibration Monitoring and HUMS activities are essential for reducing the operational and support (O&S) cost of Military and Civilian helicopters. In recent years, a significant number of VM/HUMS activities have proliferated in order to increase the safety, reduce maintenance cost, and eventually extend the life of existing helicopter fleets. In order for such VM/HUMS activities to be proven cost effective, a CBA must be preformed.

The cost effectiveness of the VMEP/HUMS system usage on the SCARNG AH-64A Apache and UH-60 Blackhawk helicopters is determined using a modification of the RITA-HUMS CBA software. Data to be collected will include aircraft details and operating, maintenance, VMEP/HUMS equipment, and VMEP/HUMS installation cost. The output from the CBAM software includes benefit and cost tables showing impact of in-flight and mission abort for aircraft with and without VMEP/HUMS, maintenance and availability, and an estimation of aircraft maintenance cost. Based on this data, projections are made for future O&S cost. This data is then analyzed to provide a break-even value for the VMEP/HUMS system on the SCARNG helicopter and determine the payback time horizon.

REVIEW OF COST-BENEFIT ANALYSIS METHOD

Currently, cost-benefit analysis (CBA) is largely used by government agencies. This is mainly due to the strong legislative actions taken by the Reagan and Clinton Administrations that issued Executive Orders endorsing the use of CBA. Executive Order 12886 on Regulatory Planning and Review, signed by President Clinton on September 30, 1993 requires agencies to perform cost-benefit analysis of proposed and final regulations. It revoked and replaced two executive orders issued under Reagan Administration: Executive Order 12911 requiring Regulatory Impact Assessment and Executive Order 12498 establishing the regulatory planning process. Moreover, the use of CBA by government agencies was enforced by Congress who enacted numerous statutes requiring agencies to perform CBA analyses.

When used by governmental agencies, CBA attempts to measure, over a relevant time period, the change in societal well-being resulting from the implementation of a governmental project or the imposition of governmental regulations. It can provide information to decision makers on the merits of the current project or regulation as well as offer a framework for comparing a variety of project or regulatory alternatives. Agencies' project or regulation evaluations are subject to the review of the Office of Management and Budget (OMB). In 1992 OMB issued the Circular No. A-94, which recommends the use of CBA in formal economic analyses of government programs or projects and provides general guidance for conducting CBA. Its goal is to "promote efficient resource allocation through well-informed decision-making by the Federal government".

CBA aims to present categories of costs and benefits in terms of dollars (so that the cost-benefit comparison can be performed with a common unit of measurement); therefore, agencies have to define and monetize all categories of costs and benefits determined by the project implementation. Sometimes practical problems appear such as obtaining data, evaluating benefits and costs, etc. Monetization of some benefits categories may be controversial because indirect methods are often employed to estimate a value for goods that are not generally traded in the marketplace (e.g. estimate the monetary value of a reduction in risk of premature mortality). In this sense OMB stipulated, "Analyses should include comprehensive estimates of the expected benefits and costs to society based on established definitions and practices for program and policy evaluation. Social net benefits, and not the benefits and costs to the Federal Government, should be the basis for evaluating government programs or policies that have effects on private citizens or other levels of government. [...] Both intangible and tangible benefits and costs should be recognized. [...] Costs should reflect the opportunity cost of any resources used, measured by the return to those resources in their most productive application elsewhere"(OMB – A-94).

Despite its recognized merit in providing important information and transparency in the governmental decision-making process, CBA was often criticized, especially by American academics who claim that CBA is an analytical technique that deals only with economic efficiency without considering who receives the benefits and who bears the costs. They also claim that CBA sometimes produces morally unjustified outcomes or it is not correctly used. Yet, it is important to highlight that CBA is a decision procedure or a method for achieving desirable results, and "some decision procedures are more

accurate or less costly than others". As long as it is used in the right way, meaning that under certain conditions agencies may need to modify the traditional approach of CBA, this decision procedure is justified if it is less costly than other procedures (e.g. risk-risk analysis, feasibility based assessment, etc.).

In order to place CBA in context, a good example is the Environmental Protection Agency (EPA) monitoring of drinking water contamination with lead. By law, EPA has to regulate the water cleaning against lead contamination. Therefore, EPA used CBA to evaluate three rules it has previously issued as to lead contamination of water. On the cost side EPA took into consideration the cost of treating contaminated water that enters the distribution system; the cost of maintaining water quality (pH level, temperature, etc.); the cost of replacing lead pipes; the cost of warning the public of high lead levels and informing it of precautions; and the cost of monitoring water quality. These costs were put in balance with the health benefits accrued from avoiding hospitalization and medical treatment of contaminated persons and compensatory costs for lost productivity. After aggregating all these costs and benefits, EPA concluded that the total health benefits from corrosion control alone would be $63.8 billion over a twenty-year period, which vastly exceeded estimated costs of $4.2 billion (Adler and Posner, 1999). Thus, with a large amount of data the CBA analysis was very transparent and convincing so it justified the adopted rule. Yet, without justification, EPA did not include in its final CBA the benefits from reducing lead damage to plumbing components, even if these benefits had been evaluated.

Some remarks have to be made. First, budgetary and time constraints may impede EPA, as well as other governmental agencies, from collecting all the necessary data. Second, when all data are available and easy to collect, agencies should try to monetize all costs and benefits and include them in their final CBA. This helps agencies to clearly present the effects of governmental projects and alert affected groups. Third, CBA is an important way for governmental agencies to defend their projects against critics coming from other agencies, as well as against legal and political challenges from affected groups. Finally, given its relative cheapness and transparency, CBA is considered the best procedure for agencies to use in evaluating their projects.

The use of CBA is not limited to governmental agencies. The U.S. Army also employs this technique in estimating whether its projects achieve an improvement in the allocation of resources.
CBA can provide valuable perspectives on the best ways to manage projects concerning the army infrastructure, labor force, capital stock etc. This approach is consistent with the Department of Defense and Army guidance and with the Army Regulation 11-18 establishing responsibilities and policy for the Army's Cost and Economic Analysis Program.

For the design and manufacturing of the helicopter AH-64D Apache Longbow, Boeing Helicopter of Mesa, Arizona put up a multidisciplinary team focused on meeting the Army's cost and performance requirements. This Integrated Product Development (IPD) team incorporated a manufacturing engineer, a design engineer, a tool engineer, and a stress engineer, and later on a material process engineer, purchasing personnel, and an industrial engineer who was called in to perform a CBA. During the project development, the team used the costing software Design for Manufacture and Assembly (DFMA) that

provided "a means of before-and-after comparison – not only against the previous models [six Apache Prototypes] but for individual redesign ideas that are part of the iterative process"(Parker, 1997). Thus through continuous CBA the best alternative was chosen and the new Apache Longbow innovative production strategies not only proved better performance and quality, but also brought savings of $1.3 billion over the life of the program.

MILITARY OPERATION AND SUPPORT COSTS

The Operation and Support (O&S) costs of US Army aviation are considerable. According to Defense Budget documents (DBD, 2000), the US Army spent $1,384M on aircraft in 1999, of which $930M were spent on modifications ($666M on AH-64A and D models), $36M on spare and repair parts, and $104M on support equipment and facilities. The Army flies around 180h/helicopter/year at a cost between $1,483/h for UH-60L Blackhawk to ~$5,000/h for AH-64D Longbow Apache. Of these flight hours, approximately 8% are used in maintenance test flights, including 5% for Rotor Track and Balance (RT&B), and 3% for others.

Table I ARIP AH-64 cost reduction high demand items for 1995-1996. (ILTI, 1996)

	NSN	NAME	CNT	QTY	PRICE	TOTAL COST	%COST	CUM%
1	1615-01-332-0702	BLADE, MAIN	301	468	$99,797	$46,704,996	43.81%	43.81%
2	1615-01-154-7076	STRAP ASSEMBLY	795	2,086	$6,670	$13,913,620	13.05%	56.86%
3	1615-01-312-2387	BLADE, TAIL	221	386	$18,467	$7,128,262	6.69%	63.55%
4	2840-01-345-2584	ROTOR COMPRES.	277	325	$18,933	$6,153,225	5.77%	69.32%
5	3040-01-352-1531	CONNECTING LINK	534	1,171	$4,703	$5,507,213	5.17%	74.49%
6	6115-01-224-9230	GENERATOR-ALT	274	329	$14,521	$4,777,409	4.48%	78.97%
7	1650-01-263-7856	CYLINDER ASSEMBLY	232	325	$9,355	$3,040,375	2.85%	81.82%
8	2835-01-164-5786	CLUTCH, ASSEMBLY	211	237	$12,467	$2,954,679	2.77%	84.59%
9	1615-01-235-5345	HOUSING ASSEMBLY	202	366	$6,674	$2,442,684	2.29%	86.88%
10	3010-01-364-2470	CLUTCH ASSEMBLY	247	496	$4,033	$2,000,368	1.88%	88.76%
11	4320-01-158-0893	AXIAL PUMP	227	313	$5,693	$1,781,909	1.67%	90.43%
		OTHERS				$10,199,239	9.57%	100.00%
					Total cost	$106,603,978		

A statistical study of AH-64 Apache premature failures performed by Innovative Logistics Techniques, Inc. (ILTI, 1996) indicated that 81% of parts removal occurred on some 40 items. Industry and government cooperation in addressing O&S costs improvements with emphasis on readiness drivers, high removal rates, and labor-intensive items, is required. Analysis of 2-year data from the Apache Readiness Improvement Program (ARIP) tracking AH-64 high demand items revealed that out of the ~$106M costs, 90% were expended on 11 high cost/demand items (Table I).

CBA OF HEALTH AND USAGE MONITORING SYSTEMS (HUMS)

The use of Health and Usage Monitoring Systems (HUMS) can significantly reduce the cost of helicopter O&S activities. Detection of incipient failure in critical components can prevent costly aircraft accidents. Whereas life extension and condition based maintenance is expected to significantly reduce the unwarranted replacement of 'healthy" parts. A major effect will come from the reduction of general vibration levels through improved Rotor Track and Balance (RT&B) procedures. Data recorded during the 1994-1996 period at the South Carolina Army National Guard – Army Aviation Support Facility (SCARNG-AASF) indicates that vibration reduction obtained through the implementation of RT&B function of the Aviation Vibrations Analyzer (AVA) could have saved $2M on TADS/PNVS visionics systems alone. At present, SCARNG-AASF is replacing AVA with the more advanced Vibrations Management Enhancement Program (VMEP) technology (Giurgiutiu *et al.*, 2000). Preliminary tests with the VMEP neural networks (NN) algorithms for improved RT&B have already shown 40% reduction in the number of maintenance test flights, and lower vibration levels when compared with existing AVA algorithms. As predicted, considerable O&S cost reduction is expected.

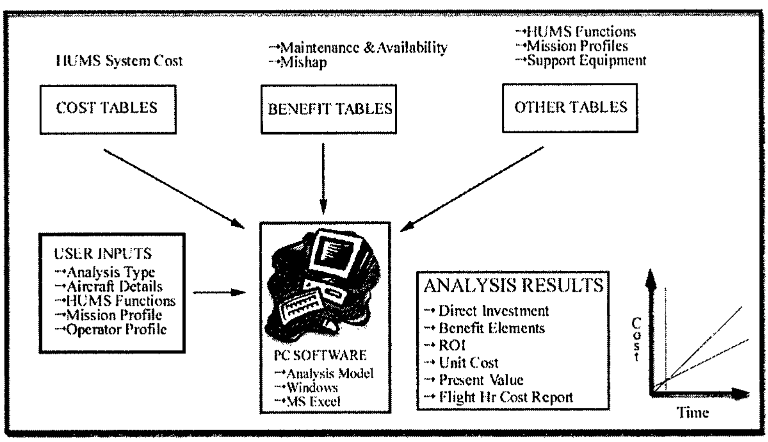

Figure 1 Overall architecture of the RITA HUMS Cost Benefit Analysis Model (RITA, 1998).

A **major obstacle** that prevents the wide spread dissemination of HUMS systems is the lack of irrefutable hard evidence that their implementation will actually reduce the helicopter O&S life-cycle costs and actually save money. Crews (1991) indicated, "many in the helicopter community have long felt that there is a direct relationship between helicopter reliability and maintainability and the level of vibrations allowed on the helicopters. This is a difficult thesis to prove for a number of reasons and skeptics have argued for hard proof that this is indeed true before they would allow significant dollars to be spent on efforts to reduce helicopter vibration." The transition from scheduled overhauls (where early removal of 'perfectly good' parts is practiced) to condition-based maintenance with 'just-in-time' replacements is expected to save considerable O&S costs. To verify this, good statistical models, carefully conducted experiments, and

statistically significant data collected on a sufficiently large sample of service helicopters are needed. Cost-benefit analysis (Nas, 1996) has been used in the past for effectiveness evaluation of space technology (Hein, 1976) and national aviation system (Noah, 1977). Booz-Allen & Hamilton, Inc. developed during 1995-1999 the RITA HUMS Cost and Benefits Analytical Model (CBAM) software (RITA, 1999) under joint funding from the US rotorcraft industry and government (Figure 1). In 1999, USC obtained access to an evaluation copy of the CBAM software for use on the VMEP project. Our analysis is planned as follows:

Thrust 1 **Cost-benefits analysis model for O&S costs at SCARNG-AASF operational unit level.** A model to track O&S costs at operational-unit level is being established for the organizational structure of SCARNG-AASF and its operational costs environment. The model will use the RITA-HUMS CBAM software framework customized to the SCARNG-AASF organizational structure. The model will track the costs associated with the acquisition, installation, and support of the VMEP-HUMS, and associated impact on the unit-level operations. The model will identify the benefits resulting from VMEP-HUMS usage in terms of increased availability, reduced mission aborts and flight mishaps, and reduction of maintenance flights for validation of replaced equipment and RT&B vibration reduction. The result of the cost-benefit analysis will be presented in terms of return on investment (ROI), present value analysis, flight hour cost reports, and a graphic representation of payback point.

Thrust 2 **Conduct statistically designed experiments at SCARNG-AASF in connection with the VMEP program.** Statistical groups of 'control' and 'exposure' helicopters will be established from the SCARNG-AASF AH-64 and UH-60 fleet. The exposure helicopters will be fitted with VMEP-HUMS equipment and will follow the VMEP-HUMS O&S procedures, while the control helicopters will be equipped, operated, and maintained in strict accordance with established Army procedures. Full data monitoring and recording will be performed on both control and exposure helicopters. The O&S data tracked during this experiment will be collected through Unit Level Logistics Systems-Aircraft (ULLS-A) and electronically transferred to the USC data repository for processing, analysis, and interpretation.

Thrust 3 **Process statistical data with data-mining algorithms to establish correlations and O&S costs trends**. Data mining is an artificial-intelligence methodology based on data analysis tools that discover data patterns and relationships suitable for prediction and extrapolation. Using data collected during the initial Thrust 2 experiments, data-mining algorithms will establish O&S cost reduction predictions that will be tested on additional data collected during follow-up Thrust 2 experiments. This iterative approach will assure model robustness and stability. Activity based costing (McDonald et al., 1998) will be used to properly track some non-technical related costs.

Thrust 4 **Verify the level of O&S cost reduction achieved through HUMS vibration management and develop cost-reduction predictions.** A number of overall cost and reliability outcomes will result from the collected data, such as: (a) time between failure (TBF) and time between maintenance action (TBMA) on critical and/or high cost components; (b) inventory costs; (c) flight time allocated to maintenance actions; (d) downtime. Besides these general trends, systematic valuation of the dollar costs and benefits associated with the VMEP program implementation will be applied. These data

will be processed with the CBAM software to reveal ROI, net present value (NPV), payback period, and future O&S cost savings.

EXPECTED BENEFITS OF USING HEALTH AND USAGE MONITORING SYSTEMS

This study will demonstrate that the use of HUMS systems may produce sizable O&S cost savings and improve affordability of Army helicopters. The benefits of the HUMS system, experienced initially by the unit-level maintenance managers, will eventually propagate through the Army Logistics Network. Process improvements at unit level, higher availability, reduced direct operating costs, and avoidance of expensive maintenance flights are the principal significant benefits expected from this study.

RULES OF A GOOD CBA MODEL

There are rules that must be followed in order to have a good CBA model. First the estimates of expected cost and benefits must be provided and clearly defined. Both the intangible and tangible benefits and costs should be included in the analysis. Cost should be defined in terms of opportunity cost and incremental costs. All cost should be inflated or deflated over the life of the analysis. The model needs to provide for the review and modification of all algorithms used in the model. The CBA model needs to calculate recurring and nonrecurring cost as well as be easy to use with good documentation of equations and help menus. These rules will provide for an efficient and well-documented CBA.

RITA-HUMS CBAM SOFTWARE OVERVIEW

There are two main components of the RITA HUMS CBAM Model. The first is the operator's module. The purpose of this module is to identify HUMS functions that provide the most value added and the maximum benefit to the operator. This includes reduction in cost per hour, the payback period, and the total dollar savings over the rotorcrafts' expected life. The second is the manufacture's module. This module gives the ability to create databases from scratch, generic databases, or an existing aircraft database. The analytical side of manufacturer's module includes the development of these aircraft databases to support the evaluation of prospective HUMS implementations. There are two distinct components in this module, the aircraft database and the analysis.

The inputs into the CBAM software include the type of analysis, aircraft details, and a definition of anticipated aircraft usage. The type of analysis includes whether the aircraft is military or commercial. The AH-64 and the UH-60 helicopters fall under the military analysis. The market value, insurance, and operating cost are entered under the input of aircraft details. The definition of the anticipated aircraft usage is inputted at this point in the software.

The outputs of the software include cost, benefit, and other tables as well as a payback graph. The cost tables include the HUMS equipment, installation, and operating cost. The benefit tables include an estimation of aircraft maintenance cost, impact of in-flight and mission abort, maintenance and availability, and mishaps for the aircraft. The individual HUMS functions, mission profiles, and support equipment are listed in other tables in the

output. The analysis results of the RITA HUMS CBAM software include the direct investment, benefit elements, return on investment, unit cost, present value analysis, flight hour cost, and a graphical representation of the payback point.

*PROS AND CONS OF THE **RITA-HUMS CBAM** SOFTWARE*

The software is user friendly when it comes to inputting the data, but several problems still exist. There is a problem with acronyms within the software. There is no explanation for the meaning of many of the acronyms involved in the software. The wizard will ask for an entry, but it will not give the definition of the acronym. There is also some confusion on why some of the data is needed in the final CBA. Because the algorithms are not clearly defined or stated, it is difficult to determine which data entries effect what in the final CBA.

One problem with the CBAM software is that it does not have the customization potential that other models have. If a cost concern is thought to affect the final outcome of the model, it is impossible to add this concern to the model. It is also difficult to see how certain inputs affect the cost benefit of the HUMS system. Certain inputs were changed dramatically with unpredictable results in the final analysis.

The help menus are useful in navigating through the input wizard, but offer very little help in the direction taken in the output. There are many pros for this model, but because it does not fit exactly the situation at SCARNG-AASF, it is difficult to get an accurate depiction of the cost savings by using this software.

CBA FOR EVALUATING VMEP

At the University of South Carolina, a research CBA module, using Excel software, has been developed. During our research, it was found that CBA is a useful way of organizing a comparison of different alternatives of a project. It can help the decision maker better understand the implications of a decision. Yet, not all impacts of a decision can be quantified or expressed in dollar terms. (e.g., intangible benefits such as aircraft availability, safety, and moral). Therefore, care should be taken to ensure that quantitative factors do not dominate important qualitative factors in decision-making.

In performing CBA for evaluating VMEP activities, we start from the baseline process and compare it to the VMEP alternative. The cost of the current process at SCARNG-AASF provides the baseline for the CBA. In our case, benefits take the form of savings and non-tangible benefits. Therefore, we first analyze the savings of the VMEP alternative by comparing the costs in the two cases. Then we discuss the non-tangible benefits of the VMEP alternative and their implications. For comparing the VMEP alternative with the baseline, we define common cost elements (Table II).

Table II Cost Elements (costs per aircraft)

	First Year		Second Year		Third Year		Fourth Year		Fifth Year		Sixth Year	
Cost Variables - (per a/c)	VMEP	Baseline	VMEP	Baseline	VMEP	Baseline	VMEP	Baseline	VMEP	Baseline	VMEP	Baseline
RT&B OCCURRENCE RATE - (a/c per year)	12	24	12	24	12	24	10	24	8	24	8	24
MAINTENANCE FLIGHT HOURS - (per a/c RT&B)	6	6	6	6	3	6	3	6	3	6	3	6
VMEP INVESTMENT - ($10K+12K/ a/c)	$22K	-	-	-	-	-	-	-	-	-	-	-
FLIGHT HOUR COST - (not including fuel)	$1.5K	$1.5K	$1.5K	$1 5K	$1.5K	$1.5K	$1 5K	$1 5K	$1 5K	$1 5K	$1 5K	$1 5K
MAINTENANCE OF HUMS ON-BOARD EQUIPMENT	$2K	-	$2K	-	$2K	-	$2K	-	$2K	-	$2K	-
PARTS - (high cost items)	$300K	$300K	$300K	$300K	$290K	$300K	$275K	$300K	$250K	$300K	$225K	$300K
MAINTENANCE FLIGHT HOURS COST - (per a/c RT&B)	$9K	$9K	$9K	$9K	$5K	$9K	$5K	$9K	$5K	$9K	$5K	$9K
OPERATIONAL FLIGHT HOURS COST	$229K	$208K	$229K	$208K	$229K	$208K	$229K	$208K	$229K	$208K	$229K	$208K

Disclaimer: To avoid un-appropriate disclosure of information, the actual dollar values have been modified, while maintaining a realistic order of magnitude.

Table III VMEP Costs for SCARNG-AASF Fleet

Year	VMEP Investment	Operational Flight Hours Costs	Maintenance Flight Hours Costs	Parts	VMEP Maintenance	Annual costs	Discount factor	VMEP Discounted Cost Flows
	I	OC	MC	P	M	AC	DF	AC/DF
1	$396K	$4.1M	$162K	$5.4M	$36K	**$10.1M**	1.0000	**$10.1M**
2	-	$4.1M	$162K	$5.4M	$36K	**$9.7M**	1.0300	**$9.4M**
3	-	$4.1M	$81K	$5.2M	$36K	**$9.5M**	1.0609	**$8.9M**
4	-	$4.1M	$81K	$5.0M	$36K	**$9.2M**	1.0927	**$8.4M**
5	-	$4.1M	$81K	$4.5M	$36K	**$8.7M**	1.1255	**$7.8M**
6	-	$4.1M	$81K	$4.1M	$36K	**$8.3M**	1.1593	**$7.2M**
Total	$396K	$24.8M	$648K	$29.5M	$216K	$55.5M		$51.8M

Table IV Baseline Costs for SCARNG-AASF Fleet

Year	VMEP Investment	Operational Flight Hours Costs	Maintenance Flight Hours Costs	Parts	VMEP Maintenance	Annual costs	Discount factor	Baseline Discounted Cost Flows
	I	OC	MC	P	M	AC	DF	AC/DF
1	-	$3.8M	$162K	$5.4M	-	**$9.3M**	1.0000	**$9.3M**
2	-	$3.8M	$162K	$5.4M	-	**$9.3M**	1.0300	**$9.0M**
3	-	$3.8M	$162K	$5.4M	-	**$9.3M**	1.0609	**$8.8M**
4	-	$3.8M	$162K	$5.4M	-	**$9.3M**	1.0927	**$8.5M**
5	-	$3.8M	$162K	$5.4M	-	**$9.3M**	1.1255	**$8.3M**
6	-	$3.8M	$162K	$5.4M	-	**$9.3M**	1.1593	**$8.0M**
Total	-	$22.5M	$972K	$32.4M	-	$55.9M		$52.0M

Yet, we cannot properly compare the two competing alternatives if we do not convert them to a common unit of measurement. Therefore, we discount future dollar values to a present value (also referred to as the discounted value). Present values are cash flows that occur now or in the immediate future and may include start-up expenses (VMEP investment) as well as any other expenses or incomes that occur at or close to the beginning of the project. Future values are the cash flows that occur sometime in the future. By converting all the future values to present values, we perform a present value analysis that will tell us what our project is worth in equivalent dollars right now. The formula we use is: $PV=FV/(1+I)^{(n-1)}$, where PV=Present Value, FV=Future Value, I=Interest Rate, and n=number of years. Tables III and IV show the annual discounted costs for both alternatives. For exemplification, we have chosen a six-year period of analysis. Cost data have been collected for estimating the costs and savings of each of the two project alternatives (baseline and VMEP) for each year of analysis. The annual costs are discounted to reflect the dollar depreciation, based on an interest rate of 3%. This interest rate was chosen based on public information about the present trends in the US economy. Figure 2 shows that in the first three years the VMEP project is more costly than the baseline, due to an initial investment of $22k/aircraft and additional VMEP

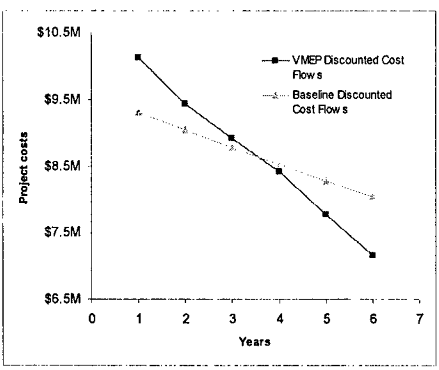

Figure 2 Annual discounted costs for VMEP and baseline alternatives

maintenance costs. However, after three and a half years the VMEP project attains the break-even point. From that point on the VMEP project costs fall sharply below the baseline costs and, consequently, savings are increasing. Furthermore, at the end of the 6-year period of analysis, the cumulative discounted cost flow for the VMEP alternative falls bellow the same cost for the baseline. Thus, a positive present value of $149,000 shows that the VMEP alternative is favorable.

The benefit variables in our analysis cannot be linked directly to a monetary value like the cost variables. They do ultimately affect the overall monetary value of the VMEP project, but cannot be linked to a dollar figure in the same way the cost variables are linked. Instead, the availability and safety variables are set up using a percentile comparison. A numeric tally is used to compare the premature parts failure, mission aborts, and the unscheduled maintenance occurrence. Moral could not be quantified in a normal scale. It is quantified by an increase in the specified year. The benefits of the VMEP project need to be looked at as non-tangible benefits and not necessarily a monetary gain. Therefore, CBA is important when VMEP and HUMS activities are essential for reducing O&S cost of Military and Civilian helicopters.

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